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CERAMIC PROPERTIES OF A CLAY FROM NORTHERN ONTARIO

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ABSTRACT

At the request of Indian and Northern Affairs Canada, a clay sample from an Indian Reserve in northern Ontario was evaluated for its applicability to production of ceramic products.

The material was found to be of exceptionally high plasticity and bond strength. However, the high content of plastic fines presumed present engenders a series of problems including high water requirement for forming (and accompanying high energy requirements for mechanical forming and drying), a marked tendency to laminar flow during forming under high pressure, high drying shrinkage, high firing shrinkages at low porosities applicable to impermeable pottery or structural clay products to be exposed to the elements.

The material alone would be suited only to production of low quality porous earthenware or porous structural products such as farm drain tile or partition tile. Most of the deficiencies could probably be remedied by the addition of fine sand, which would improve forming and drying properties and reduce firing shrinkages, thus extending the viable firing range and possibly enabling production of dense types of ware.

INTRODUCTION

A sample of clay from an Indian Reserve in northern Ontario was submitted by G. Berssenbrugge, Surficial Geologist, Indian and Northern Affairs Canada, Indian Minerals (East) Directorate, for evaluation as to its potential for clay products with particular reference to pottery and bricks. The work was performed under Project 3.0.2.9.99, Cost Recovery-Ceramics, Job No. 025271.

MATERIALS

The sample consisted of approximately 1500 g of wet clay, which produced 1130 g of oven-dried material. The clay was brownish red, very fine grained, apparently from a uniform, massive deposit. It contained pink relicts, remeniscent of very small, very thin shells. These inclusions effervesced moderately when treated with dilute HCl, indicating carbonates. The matrix of the clay effervesced only slightly with HCl, indicating low lime content.

PROCEDURES AND RESULTS

The sample was oven-dried at 105°C for 24 h, then ground to pass a 14-mesh Tyler screen.

Plasticity

A representative 200-g aliquot of the dry sample was submitted to examination using the Brabender Plastograph. The procedure, standard in this Laboratory, was for continuous water addition at the rate of 1% per min with the instrument operating at "slow" speed. No significant change in plasticity was observed before about 23% water addition, indicating the very fine particle size of the clay and the resultant need for a large amount of water to wet the high surface area. The material then began to develop its inherent plasticity, with the consistency rising to 1000 metre-grams of torque at about 28% water addition and continuing to rise to beyond 2000 m-g at 28.75%, and to exceed the capacity of the instrument, breaking the protective shear-pin and concluding the test. It can be thus inferred that this material is exceedingly strong and plastic,

considerably more so than many commercial ball clays. Some of the residual material from the instrument was further examined and found to become smoothly plastic (considered suitable for pottery making on the wheel) at a water content of about 38%, i.e., in the range corresponding to beyond the peak plasticity. Such a material, at peak plasticity, would require excessive pressure for forming, e.g., very high power for extrusion.

Extrusion Test

The sample was prepared for extrusion in a Hobart mixer, with 36% water addition, judged to be suitable by experienced operators. Briquettes measuring 2.5 x 2.5 x 9 cm were extruded under vacuum of 28 inches of mercury using a Midvale-Heppenstal hydraulic extrusion press. Identification numbers and shrinkage marks were applied to the freshly extruded specimens. Extrusion at this water content required approximately 3 tonnes total pressure, which is normal for brickmaking or pottery bodies. The extruded column showed pronounced corner tearing (dog-earing) as a result primarily of friction of the flowing clay against the die liner. The latter was obviously too long for material of this high plasticity.

Drying Behaviour

One freshly extruded briquette was inserted directly into a laboratory oven at 100°C. This rather severe exposure is used to reveal potential drying problems. No cracking of the test specimen occurred, indicated safe drying of products of this clay. The remainder of the briquettes were dried overnight at ambient temperature and then final-dried at 105°C, without any evidence of cracking. Drying shrinkage was measured to be 8.3% of wet length. The safe drying characteristics of the sample, in spite of the high drying shrinkage, are clearly related to its high bond strength related to the inherent high plasticity, as evidenced by the specimens' high dry strength: when tested in flexure between an operator's fingers, they would not break.

Firing Behaviour

Duplicate specimens were fired in electric-resistance laboratory kilns at temperatures of 991, 1050, 1101 and 1152°C (Pyrometric Cones 06, 04, 02, and 3 respectively). Cooling was at the natural rate of the furnace. Fired shrinkages were measured and calculated on the basis of wet length, thus are directly additive to drying shrinkage. Fired water absorptions were determined on the basis of both 24-h cold soak and 5-h boil. The results are plotted in Fig. 1. The variance between absorptions was minimal, except for the specimens overfired at Cone 3, where the body was vesiculated and contained a proportion of sealed pores, which filled only on boiling. The material fired at Cones 06, 04 and 02 was free of cracks and/or deformation, again an indication of the high bond strength of this material. At Cone 06 the fired colour was light salmon, darkening somewhat at Cone 04 and becoming brownish red at Cone 02. It was dark brown and bloated at Cone 3. At all firing temperatures there were very small white specks, attributed to the shell relicts observed in the raw material.

CONCLUSIONS

1) The material is virtually unique in terms of its high bond strength, which preserved it from cracking or warping in spite of drying shrinkage of 8.3% and firing shrinkages ranging up to 10.7%. Although this provides for high dry strength (and easy safe handling of dry ware), it requires application of high forming pressure unless the material is combined with sufficient water to exceed its peak plasticity.

2) The high plasticity is presumed due to a high content of extremely plastic fine clay particles, to wet the surfaces of which requires a high water of plasticity which would require much more than average energy for drying.

3) The fine particle nature of the material renders it subject to die lamination during extrusion. This problem could probably be overcome through use of a very short forming section of the die, as opposed to the long-section die used in this Laboatory. This characteristic could cause surface lamination problems on forming e.g., pottery on the wheel or mechanical jigger.

4) The material has a short firing range for vitrified ware. Thus, it could be suited to earthenware fired in the high absorption (and relatively low shrinkage) temperature range of Cone 06 to 04. However, for dense, impermeable pottery or brick the shrinkage and absorption varies widely with temperature from Cone 04 to 02 and quality control of uniform properties would be difficult or impossible under large scale or commercial operating conditions.

5) Thus, except for porous ware such as flower pots or some types of structural tile, the material by itself would be unsuited for use. Most if not all of its shortcomings could probably be rectified by the addition of a quantity (probably 25-30 weight per cent) of fine sand. Such a sand would preferably have a particle size distribution from circa 35 mesh to 16 mesh, and consist of silica or silica/feldspar free of carbonates, which themselves would give rise to lime-popping. Sand additions of this type would improve forming behaviour (i.e., reduce laminations), reduce drying and firing shrinkages (effectively broadening the firing range to an acceptable temperature difference) without decreasing strengths below an acceptable value.

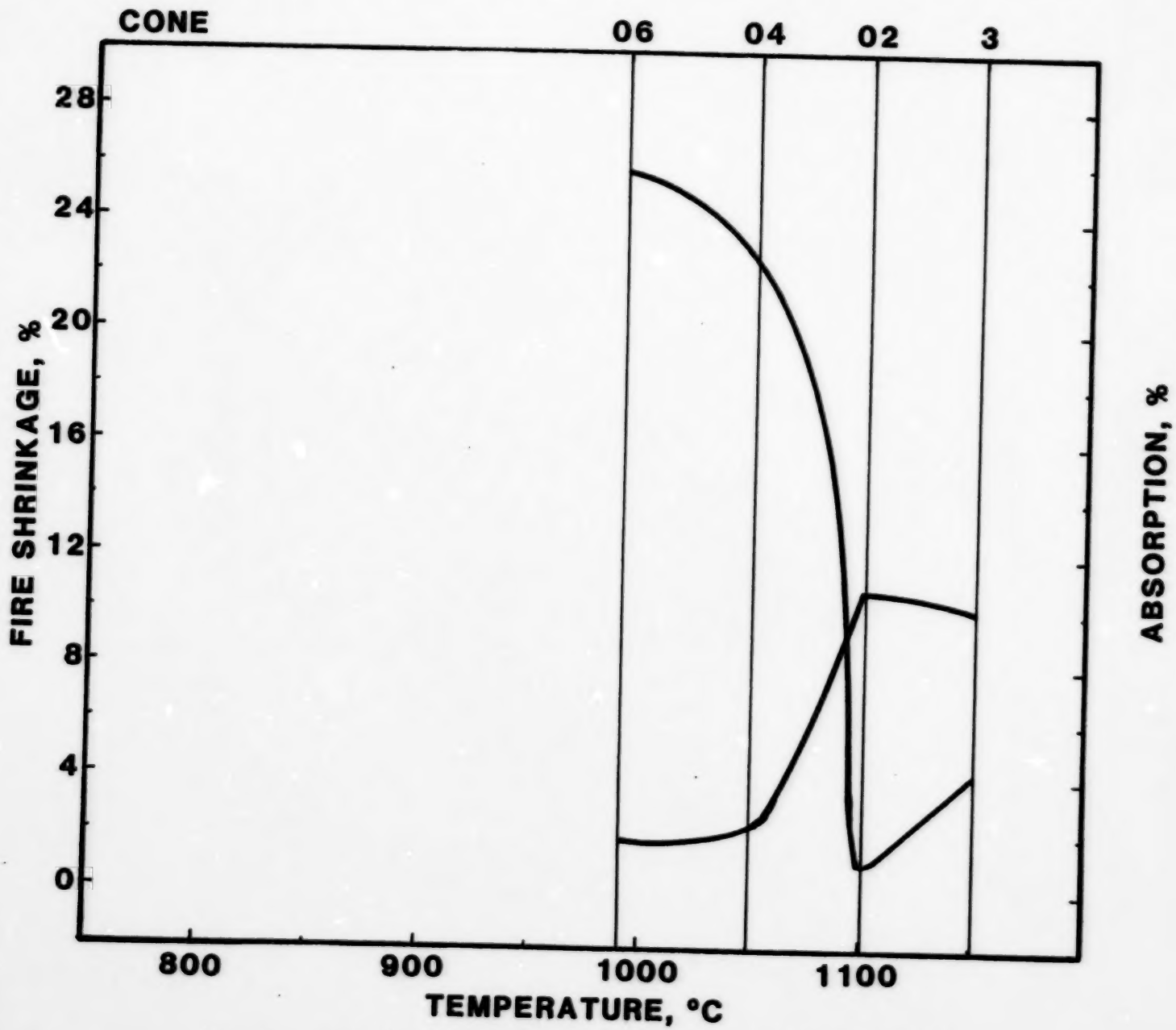

Fig. 1 - Variation of product properties with firing temperature.